Modeling of a Counter Flow Plate Fin Heat Exchanger

Ruoxu Jia
Junling Hu
Xingguo Xiong

University of Bridgeport

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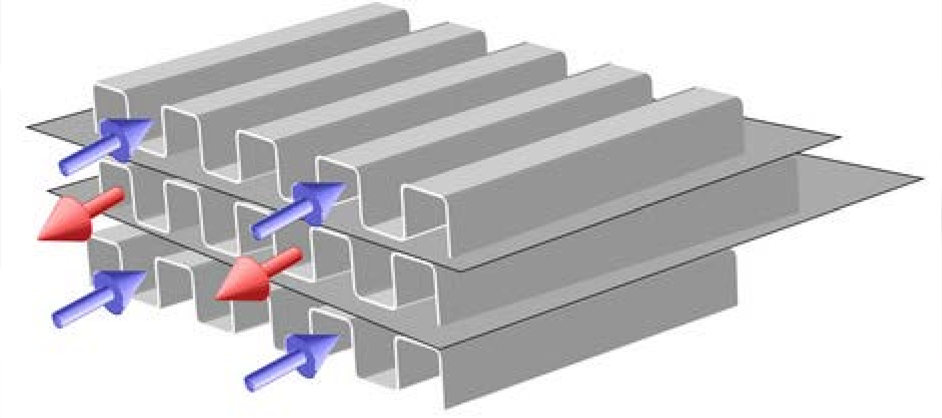
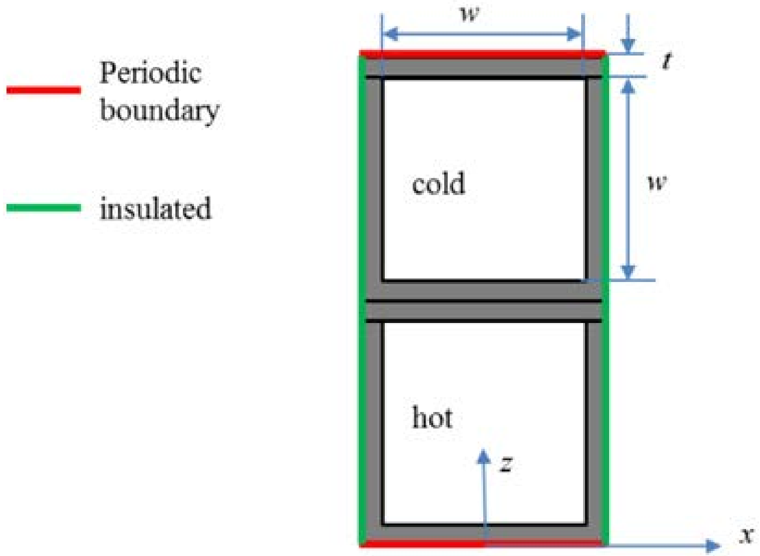
Introduction

Heat exchangers are used widely in many industries for heat recovery or cooling purposes.



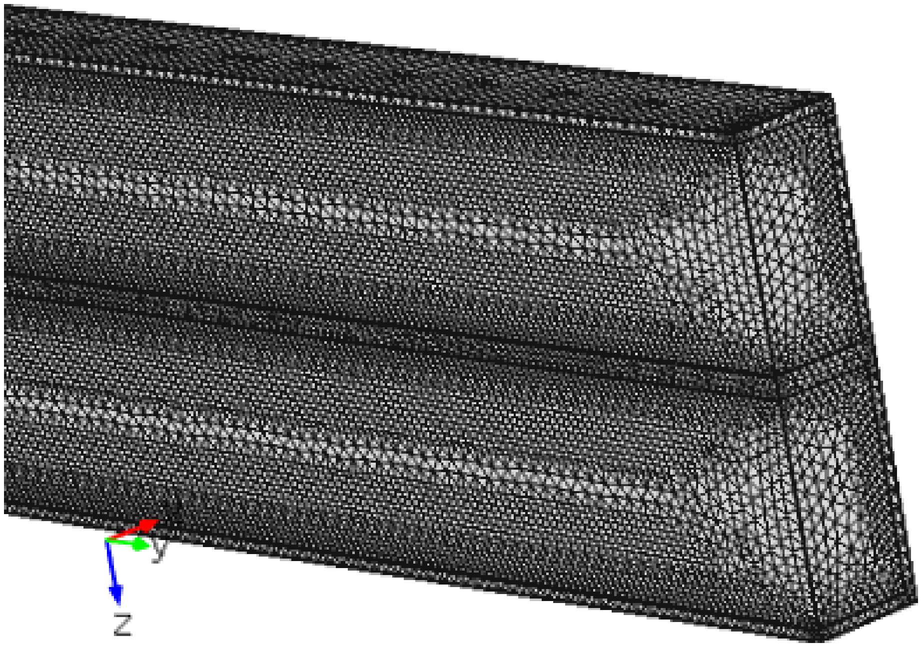
Schematic of a counter flow plate fin heat exchanger

This simulation is the heat transfer and fluid flow in a multilayered counter flow plate fin heat exchanger. The temperature distributions and heat transfer rate are analyzed to study the performance of the heat exchanger

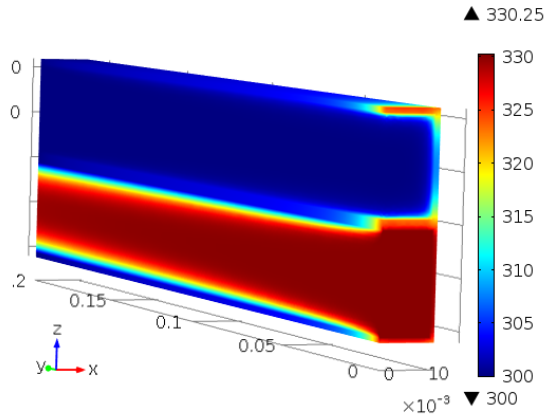


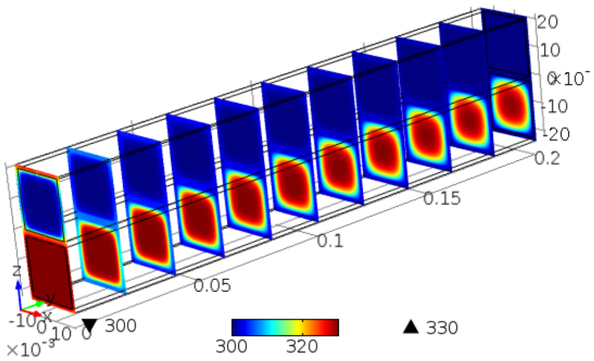
Side view of the computational domain consisting of one cold and one hot channel

The conjugate heat transfer problem was solved using the Heat Transfer module of COMSOL 4.3b.



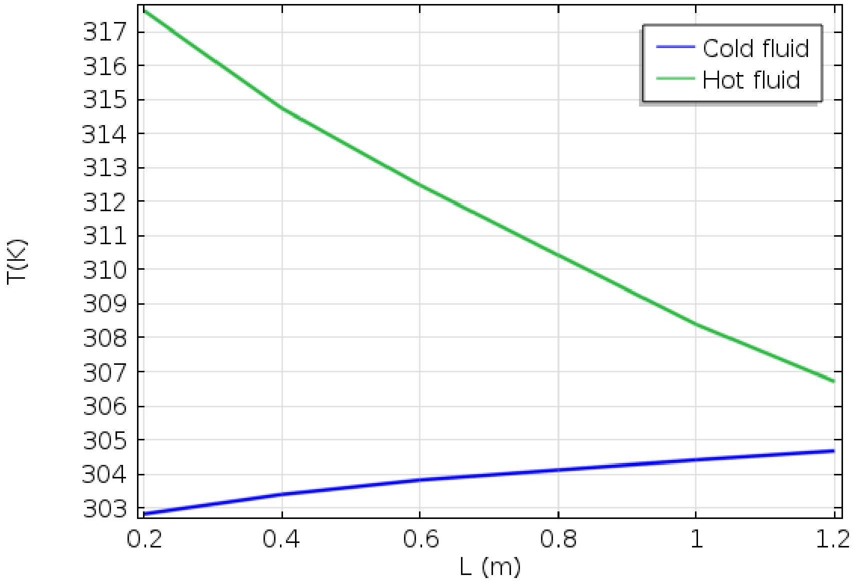
Results



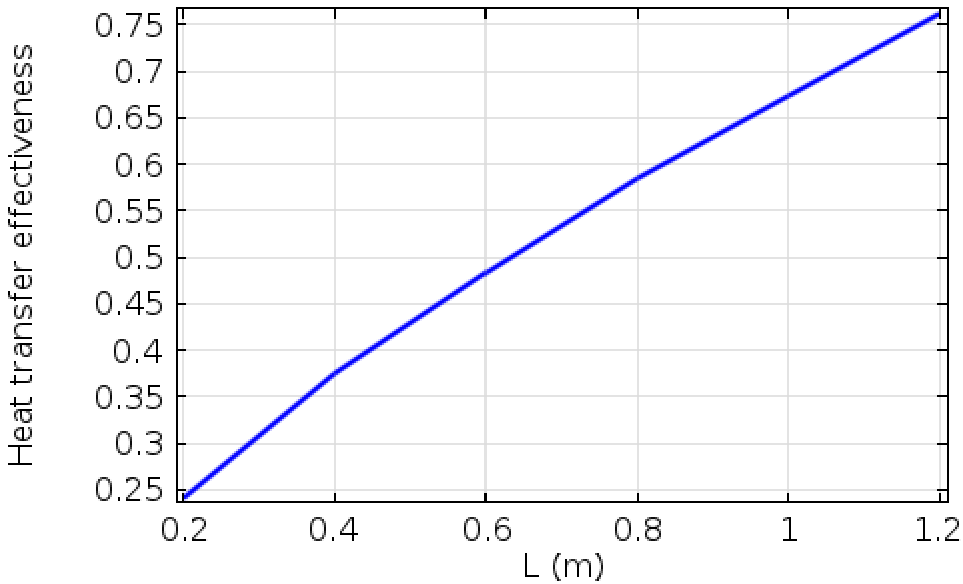


Hot oil enters the bottom channel with a uniform temperature of 330K and is cooled along the channel length and cold water enters the top channel with a temperature of 300K and is heated along the channel length.

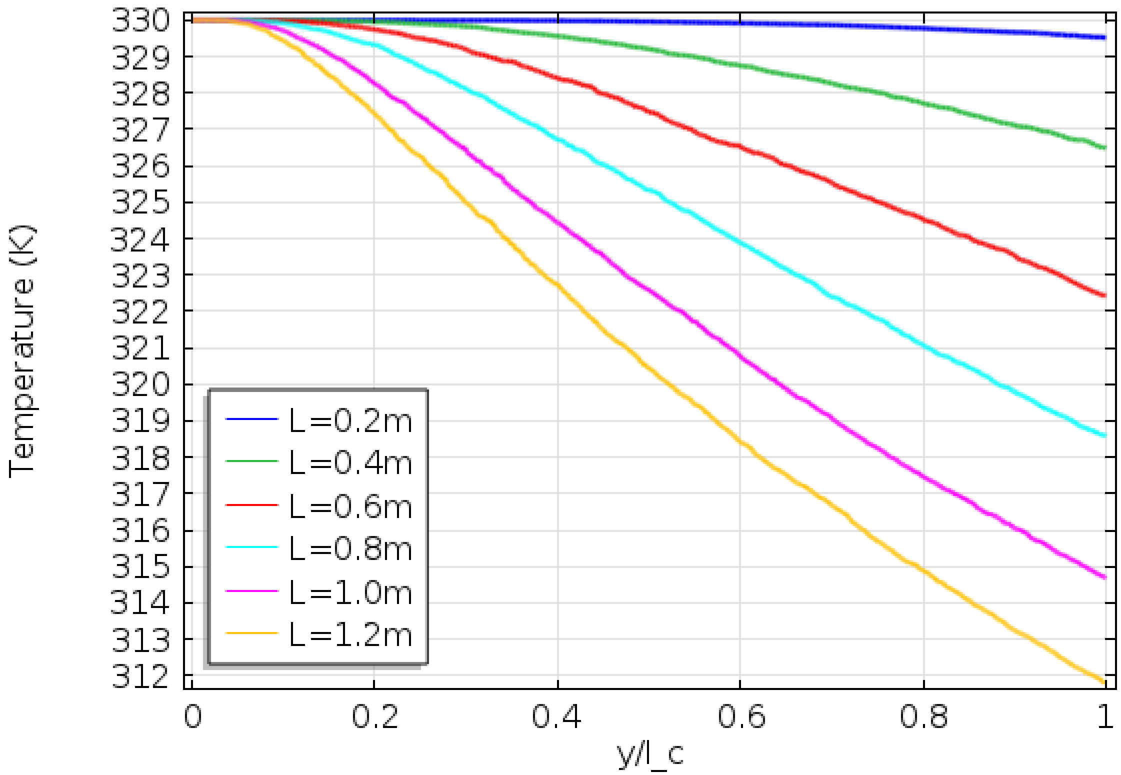
The average temperature drop for the oil is higher than that of water as a much higher heat capacity rate is used for water.



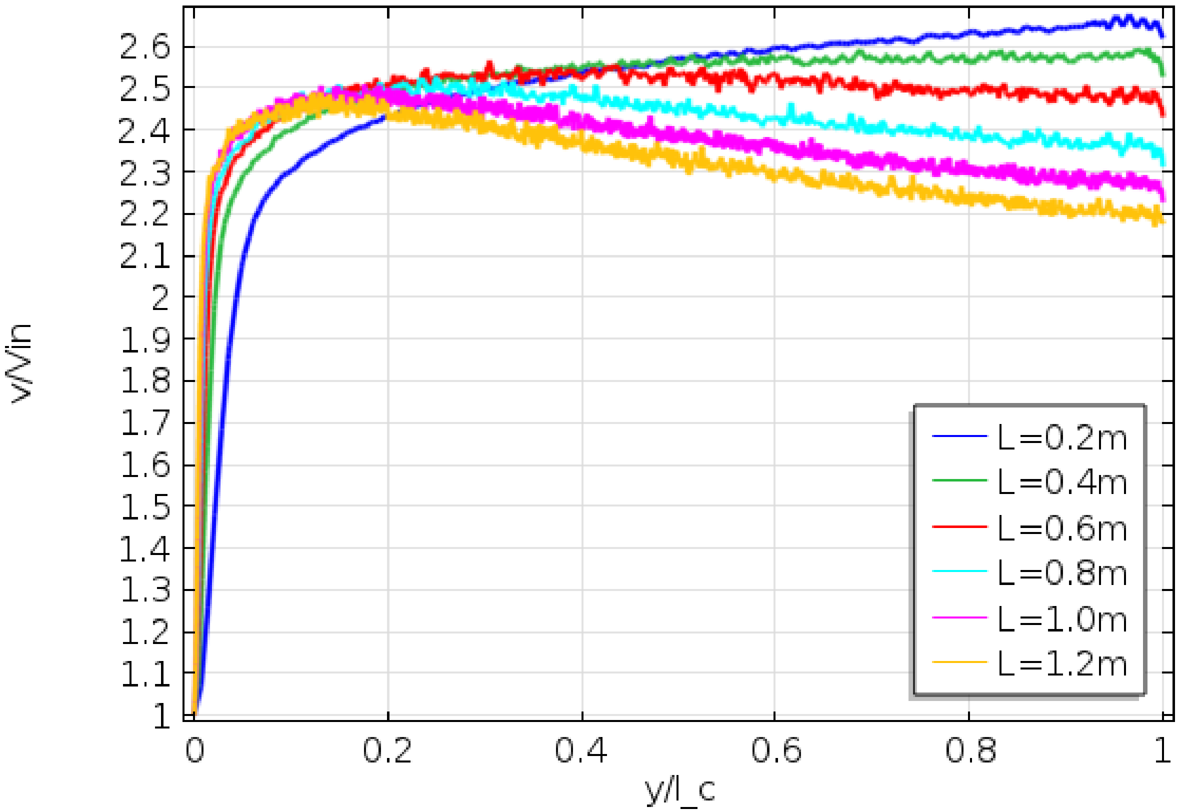
Average fluid temperature at the channel exits vs channel length where the maximum heat transfer rate is calculated as the heat capacity rate of oil multiplied by the temperature difference of the inlet temperatures.



Heat transfer effectiveness obtained with various channel length

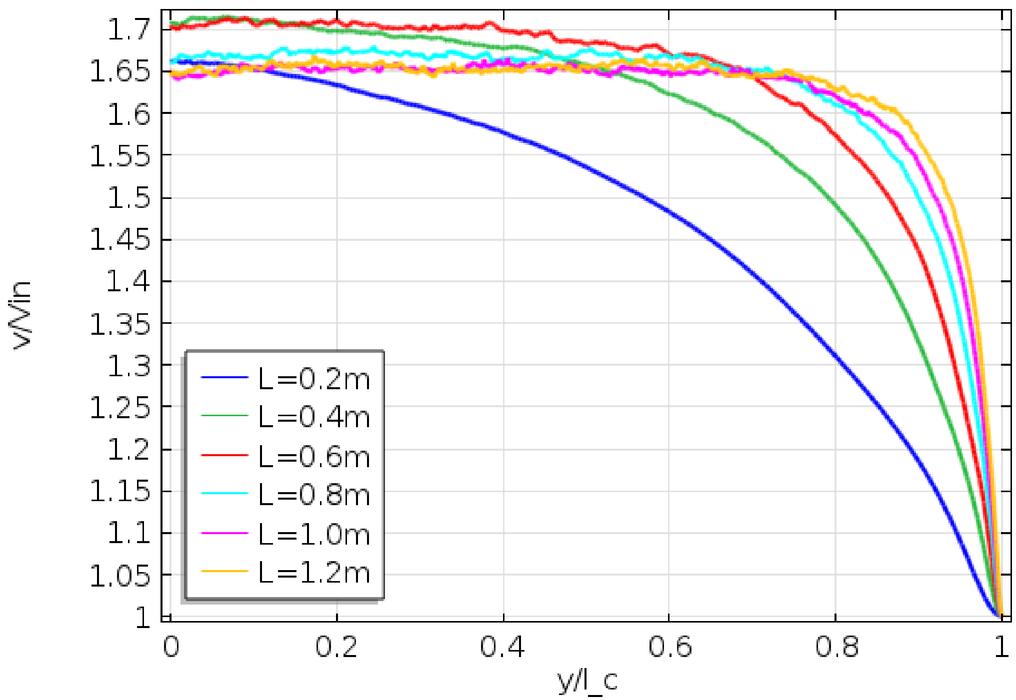


Fluid temperature along hot channel centerline



Streamwise velocity along hot channel centerline

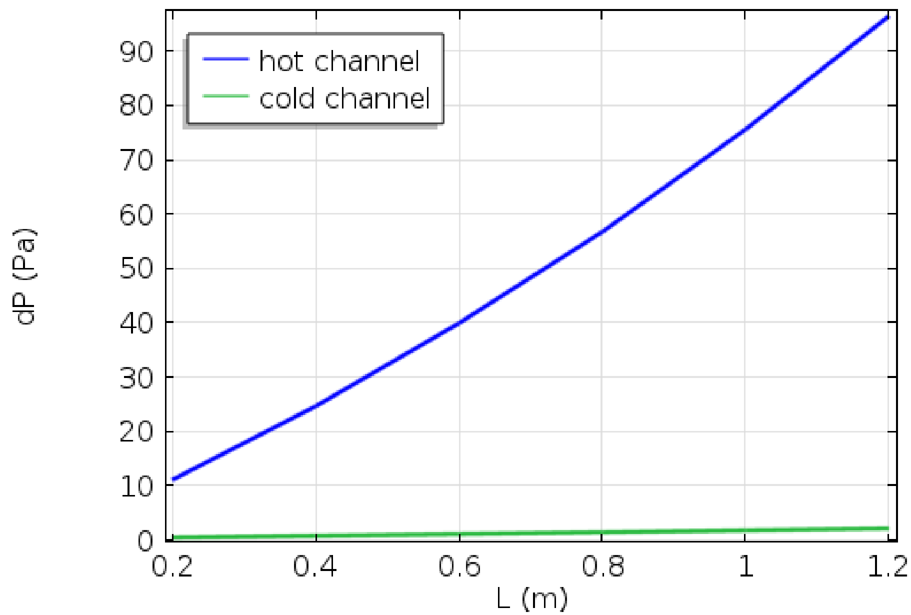
The Prandtl number of water varies in a range of 3.60-5.90 in the cold channel.



The centerline velocities show that fluid in the hot channel reaches a fully developed state very quickly at the entrance, which is close to the theoretical value of 0.001m for the hydrodynamic entrance length. The approximate thermal entrance length can also be calculated to be 1.25 $L_t = P_r L_h$. . Prandtl number is defined as the ratio of momentum diffusivity to thermal diffusivity of fluid.

As the Prandtl number of oil is in the range of in a range of 1220-6185 in the hot channel.

The pressure drop in the hot channel is about 50 time of the pressure drop in the cold channel as the viscosity of oil is much higher than that of water. Therefore, a high flow rate of water can be used to increase heat transfer effectiveness without significantly increasing pressure drop.



Conclusions

In this study, a 3D model of a counter flow plate fin heat exchanger was developed to simulate the heat transfer and fluid flow in a unit cell composed of one cold channel and one hot channel. The model was simulated in COMSOL 4.3b Heat Transfer module with oil and water as two working fluids. The detailed temperature and velocity distributions are presented for a better understanding of the heat transfer phenomena in a heat exchanger. The hydrodynamic and thermal entrance lengths are compared with the theoretical results and good agreement are found. A parametric study was conducted to show the effect of channel length on the temperature distribution, heat transfer effectiveness, and pressure drop. The established model can be further developed to optimize a heat exchanger with similar geometry.

Questions?

Thank you